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Uber ATG

Uber ATG Party Submission to the National Transportation Safety Board (N.T.S.B.)

For the Vehicle Crash:
Tempe, Arizona; March 18, 2018

NTSB Crash #HWY18FH010

I. Introduction

In accordance with the rules of the NTSB,[1] Uber Advanced Technologies Group ("Uber ATG") provides this party submission concerning the fatal crash that is the subject of this investigation.

In March of 2018 an Uber ATG test vehicle, that was under human supervision, struck and killed a pedestrian in Tempe, Arizona. Uber ATG remains deeply regretful for this crash and has worked closely with the National Transportation Safety Board, The National Highway Traffic Safety Administration, and local and State officials throughout their respective investigations to fully understand the facts surrounding this tragic event. We are committed to continuous improvements and have used the facts from these investigations and other sources to enhance our self-driving program and to sharing our learnings on safety with the broader industry.

Following the crash, Uber ATG immediately ceased operating on public roads and conducted a top-to-bottom internal safety review of our organization and our approach to self-driving system development and testing. In addition to this internal review, Uber ATG commissioned and released an independent, external review of the safety culture at Uber ATG by the LeclairRyan firm.[2] These reviews were broader in focus than the limited circumstances of the crash in Tempe, and identified significant potential safety improvements across the entire organization and technology stack. Over the last eighteen months, Uber ATG has sought to implement these improvements, while collaborating on best practices with others in this industry in order to encourage the open exchange of information and learnings that will be essential to realize the full potential benefits of this technology.

Uber ATG offers this submission to both describe several of the safety improvements we believe are most impactful in light of this crash, and to describe the process we have undertaken to reinforce the safety driver role, enhance safety culture throughout the organization, and collaborate with the broader industry towards advancing all of our collective safety practices.

We also note that Uber ATG's automated driving system (ADS)[3] was, and still is, a system under development. Eventually, we intend for our self-driving vehicle to be capable of

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[1] *See, e.g.*, 49 C.F.R. § 831.14.

[2] See LeclairRyan PLLC, "Independent Review of the Safety Culture of Uber Technologies Inc.'s Advanced Technologies Group: Final Report" at 24-28 (2018), available at https://www.leclairryan.com/files/upload/ATG%20Final%20Report.pdf (hereinafter, "LeclairRyan Report"). For a more fulsome description of both the internal and external reviews, see Uber ATG, "Safety Report Supplement: Internal and External Safety Reviews" (2018) (available at https://uber.app.box.com/v/UberATGSafetySupplement).

[3] https://www.sae.org/standards/content/j3016_201806/

completing an entire journey without a safety driver within a specific Operational Design Domain (ODD).[4] Our development process involves rigorous track testing and other forms of testing before software is released for public road testing. That said, during development, the safety driver, continues to play a central role in ensuring the safe operation of the vehicle. As such, we have devoted significant attention to improving the effectiveness of this role, along with mitigations to address distraction, fatigue, and fitness for duty.

II. Enhancements to Support the Safe Testing of Automated Vehicles

This submission will not endeavor to describe all of the safety improvements that resulted from the thorough internal and external review processes cited above. Those reviews helped contribute, for example, to meaningful technological improvements -- such as the utilization of an independent automated emergency braking system, reduced system latency, improved roadway-user identification, additional safety driver alerts, and others. Uber ATG has previously made available publicly a more detailed description of these improvements across all subject matter areas in a variety of contexts.[5] But in light of the core facts of the crash as described in the various Chairman's Factual Reports, this submission will instead highlight a subset of the improvements that Uber ATG has undertaken over the last eighteen months that speak specifically to operational safety.

A. Selected Enhancements in the Hiring, Training, and Monitoring of Safety Drivers

As the Board notes throughout the Chairman's Factual Reports, a safety driver[6] plays a particularly important role during the early and intermediate testing stages for self-driving technology. During these developmental stages, a self-driving vehicle may need to return control to the safety driver or the safety driver may need to disengage the autonomy system.

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[4] Such a system differs from the Level 2 systems currently available on production vehicles where two or more advanced driver assistance systems can, for limited times, control the braking, steering or acceleration of the vehicle.

[5] *See* Uber ATG, "A Principled Approach to Safety" (2018) (hereinafter, "Uber ATG VSSA"); Uber ATG, "Laying the groundwork for self-driving vehicle safety" (2018); Uber ATG, "Safety Report Supplement: Internal and External Safety Reviews" (2018).

[6] This submission utilizes the term "safety driver" to refer to the human or humans who are physically present in a developmental self-driving vehicle and are tasked with (i) manually driving the vehicle when autonomy is not engaged, (ii) monitoring the performance of the ADS when engaged, and (iii) disengaging the ADS (and resuming manual driving) where necessary for the safe operation of an AV. Various other documents may refer to this same role as a "vehicle operator." Uber ATG utilizes the term "mission specialist" when referring to the set of professionals who have undertaken this role for Uber ATG since a re-design of this role in 2018 (a set of improvements to be described in more detail herein).

This was Uber ATG's approach to testing our self-driving system around the time of the crash, and it remains our approach today. With the Uber ATG system at a developmental stage that -- in March 2018 -- would not allow for exclusive reliance on the self-driving system to detect and react to everything in the roadway environment, the Uber ATG safety driver played a key role in promoting safe testing by monitoring the roadway and the system and executing manual driving duties as needed. The broader regulatory community has likewise recognized the important role played by the safety driver in promoting safe self-driving testing. For example, in its most recent guidance on Automated Vehicle Policy, the U.S. Department of Transportation has stressed the singular importance of the safety driver, noting that "Safety drivers serve as the main risk mitigation mechanism" during early self-driving development testing efforts, and that "[s]afety-driver vigilance and skills are critical to ensuring safety of road testing."[7]

Towards this end, Uber ATG established our own safety driver program to support drivers in executing their responsibilities. Our program included, as the Chairman's Factual Reports accurately note, a prohibition on in-vehicle cell phone use.

Mindful of the central role played by a safety driver, we have over the last eighteen months reviewed every aspect of our safety driver program, with the goal of maximizing the effectiveness of the role.

Perhaps the most important means of empowering safety drivers to oversee self-driving testing operations is a training regime that prepares safety drivers for the realistic experience of testing and operating a developmental self-driving vehicle. As LeclairRyan's report noted, training provides one of the key mechanisms for overcoming the inherent challenges (across different industries) in asking human operators to monitor largely automated systems.[8] Uber has redesigned our training for Uber ATG safety drivers. Among other improvements, the revised training includes a particular emphasis on the following elements of self-driving vehicle operation:

- Safe manual driving, with attention to emergency maneuver exercises, navigating occluded areas, and defensive driving among other areas of focus.
- Technical education on the self-driving system, to bolster safety driver understanding of the vehicles they will be operating, and expectations for particular vehicle features, such

[7] *See* U.S. Dep't of Transp., "Automated Vehicles 3.0: Preparing for the Future of Transportation" at 37-38 (2018) (hereinafter, "FAVP 3.0"). The Department of Transportation's guidance also recognizes that the safety driver's responsibilities recede and ultimately disappear as a self-driving vehicle progresses towards being able to execute all aspects of the dynamic driving task. But for self-driving vehicles at or around the stage of development of the self-driving vehicle involved in the crash, the safety driver undoubtedly serves as the centerpiece of any safety assurance strategy, as the developmental system should not – at such a stage – be expected to fully execute driving responsibilities. Various state governments have similarly focused on safety driver training and qualifications as possible appropriate subjects of state regulatory activity.

[8] *See* LeclairRyan Report at 24-28.

as the base vehicle's Automatic Emergency Braking system and other native safety equipment.

- Training on piloting and co-piloting,[9] which covers, among other items, engagement and disengagement procedures for the Uber ATG self-driving system, and how to respond appropriately to various system faults. Additionally, the training program described herein provides techniques for safety drivers to ameliorate the risk of distractions and fatigue while piloting. Co-pilot training is tailored to the responsibilities of the second Mission Specialist in the vehicle -- a position that we view as appropriate under the system's current developmental state.
- Continuous education, to provide safety drivers with information on new capabilities and functionalities. This includes annual recertification training to ensure drivers continue to meet basic performance requirements as well as a refresh training program, where needed, for safety drivers who have spent time away from regular driving duties.

Additionally, we have sought to complement this improved training program with attention to safety both before and after training. Our hiring practices prioritize candidates who appreciate the importance of an organization-wide commitment to safety. And we have implemented monitoring programs to provide real-time monitoring for distracted driving (a system which alerts the driver and headquarters if it detects distracted driving), as well as a system that alerts a manual driver who has exceeded the speed limit.

B. Selected Enhancements in Safety Culture

Prioritizing safety requires an organization-wide commitment to safety as a matter of culture. Against this backdrop, ATG has endeavored to supplement specific improvements in the safety driver role with organization-wide safety culture improvements. The following represent some illustrative examples of these types of advancements:

- Implementing a Safety Management System tailored to developing self-driving technology: A common framework in aviation and other safety-critical industries, a Safety Management System provides a whole-of-organization approach to risk, safety policy, safety communications, and other important drivers of safety culture. Uber ATG has been leveraging experience from these other safety-critical industries to apply this framework to the development of self-driving technology.[10]
- Establishing a safety concern reporting system: Uber ATG has implemented an internal confidential safety concern reporting system designed to collect valuable feedback from anyone on our team. We openly encourage our employees to raise -- without fear of retaliation -- awareness of any concern that, if addressed, has the potential to improve the safety of our self-driving operations.

[9] *Cf.* Uber ATG VSSA at 42-43.
[10] *Cf.* LeclairRyan Report at 15.

- Stand-Ups for Safety: Over the last 18 months, Uber ATG has held multiple Stand-Up for Safety events at our offices around the country.[11] These whole- or half-day events, during which other work is suspended, allow all staff the opportunity to learn about our safety goals and approaches, and to hear from external safety experts on developments in the field.
- Self-driving Safety and Responsibility Advisory (SARA) Board: Uber ATG has established an independent board of industry and academia experts to consult, advise, and review our approaches to safe operations, among other matters.

C. Industry-driven Self-Driving Vehicle Consortiums and Standards Bodies

Continuous improvement requires continuous receptivity to new or improved practices. As a result, over the past year, we have joined numerous self-driving-related standards bodies, consortiums, and partnerships. These engagements both allow Uber ATG to share the benefits of our experiences, but also provide a forum in which we can remain attuned to learnings from industry players, regulators, and other subject matter experts. These various fora provide Uber and other industry players a steady stream of lessons that will continue to benefit the safety of self-driving technology at Uber and in the industry more generally. A sampling of these types of efforts are described below:

- SAE Automated Vehicle Safety Consortium - Consortia to establish safety and testing principles and best practices focused on the safe deployment of SAE Level 4 and Level 5 ADSs.
- SAE On-Road Automated Driving Committee - Committee responsible for developing and maintaining SAE standards, recommended practices, and information reports related to motor vehicle driving automation systems.
- Safety Case Framework - Earlier this year, we publicly released our Safety Case Framework for self-driving vehicles during development and into deployment with the goal of providing additional transparency around our safety approach.[12]

III. Conclusion

In the months since the tragic crash in Tempe, we have recognized an immense opportunity for improvement on safety. This process of improvement was aided by our own reviews and the thoroughness of the investigative efforts by the NTSB and other government entities. Because safety is a shared responsibility, we have endeavored to widely share our learnings in this area -- both through this submission, and through a series of other public engagement efforts.

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[11] *See* LeclairRyan Report at 19.
[12] *See* Uber ATG, Our Safety Case (2019), available at https://uberatg.com/safetycase/.

While we are absolutely committed to safe development and deployment and continuous improvement on safety, we recognize that the self-driving industry's path through development to deployment will present challenges. In anticipating and addressing these challenges, Uber looks forward to continuing transparency around our approaches, learnings, and challenges -- with the public, with government entities, with industry, and all other stakeholders.